

NORTHWEST ROAD BRIDGE

(Quarry Bridge)

Northwest Road spanning Little River,
two miles south of U.S. Route 20

Westfield

Hampden County

Massachusetts

HAER No. MA-142

HAER
MASS
7-WESF,
3-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD

National Park Service

Northeast Region

U.S. Custom House

200 Chestnut Street

Philadelphia, PA 19106

HISTORIC AMERICAN ENGINEERING RECORD

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HAER
MASS
7-WESF,
3-

Location: Northwest Road spanning Little River, two miles south of U.S. Route 20,
Westfield, Hampden County, Massachusetts
UTM Coordinates: 18.679940.4666320
USGS Quadrangle: Blandford, Massachusetts

Date of
Construction: 1887

Fabricator: Berlin Iron Bridge Company, East Berlin, Connecticut

Present
Owner: Westfield Department of Public Works
59 Court Street
Westfield, Massachusetts 01085

Present Use: Vehicular bridge.
Anticipated date of replacement: 1997.

Significance: The Northwest Road Bridge is the second-oldest of four lenticular pony truss bridges and the fifth-oldest of seven extant lenticular trusses of all types in the Massachusetts Highway Department data base. It is the most typical pony truss example of William O. Douglas's first patent, among the three such examples in the data base. It is notable for such early features as the tapered floor beams, looped-rod floor beam hangers, and the floor-level wind-truss struts in every panel—features not commonly found in later lenticular truss bridges. The bridge was manufactured by an important late-nineteenth-century bridge fabricator, the Berlin Iron Bridge Company, and is a rare surviving example of a type of metal truss bridge that was once common in Massachusetts.

Project
Information: This documentation was initiated as a mitigation measure prior to the Federally funded replacement of the Northwest Road Bridge by the Massachusetts Highway Department. This documentation was prepared between November 1996 and April 1997 by:

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Site Description

The Northwest Road Bridge¹ carries Northwest Road over Little River, a half-mile east of Westfield Mountain, in the City of Westfield, Massachusetts. The bridge is surrounded by picturesque, relatively open woods flanking a wide, shallow streambed. The northwest section of Westfield, historically known as West Parish or Mundale, is a sparsely populated rural community which was, in earlier years, the center of several small industries, including powder keg manufacturing, whip manufacturing and marble quarrying.

Bridge Description

The Northwest Road Bridge is a single-span, wrought iron, pin-connected lenticular pony truss bridge supported by mortared rubble stone abutments. The truss superstructure measures 74'-0" long (center-to-center of end pins), 16'-0" wide (out-to-out), and 8'-0" high (center-to-center of pins at mid-span). Each truss is composed of six panels, with a uniform 12'-4" panel length. The clear span between abutments is 72 feet, and the clearance from the riverbed to the bottom of the floor beams at mid-span is 10'-0". As the word "lenticular" suggests, the upper and lower chord segments form mirror parabolic profiles.

Each segment of the truss upper chords is a built-up, riveted member comprised of two 7"x1/4" side plates, one 14"x3/16" top plate and four 1-3/4"x3/16" angles, connected on the underside with lacing and tie plates. Each endpost is built up in a similar manner; each originally had a two-piece cast iron cap covering the shared upper/lower chord joint. The date "1887" is cast into the raised upper panel of the northwest endpost cap, (and a partially obliterated date appears on the raised upper panel of the badly deteriorated northeast endpost cap.) The upper pieces of the endpost cap castings are completely missing from the southeast and southwest endposts. A horizontal base plate is riveted to the foot of each endpost. The lower chord is comprised of paired 1"x3" eyebars. The upper and lower chords are connected with tapered vertical members, or "web posts," consisting of four 1-3/4"x3/16" angles with lacing. Single loop-welded rod diagonals (1-1/4" diameter) and counters, each provided with a turnbuckle, brace the four central panels. The truss members are connected at each upper and lower panel point by 3-inch diameter pins secured at each end by 4-inch diameter nuts.

The floor system includes five built-up, plate girder floor beams, each comprised of a tapered 1/4-inch thick web plate and paired top and bottom flange angles (3"x2"x1/4"). The beams taper from 24" at the center to 12" at the outer suspension points. The floor beams are hung from the lower chord pins by U-shaped, 1-1/8" square rod hangers. The hangers loop over the pins at each lower chord panel point, pass through notches cut into the flanges of the floor

¹ Apparently, this bridge was never given an official designation, as town/city documents consistently describe the structure's location (e.g. "the bridge crossing Little river between the boulevard and West Parish"), rather than refer to it by a particular name. The name "Quarry Bridge," presumably coined in a 1921 inspection report by the Boston engineering firm Fay, Spofford & Thorndike, and subsequently carried over into Massachusetts Highway Department records, makes historical reference to the Westfield Marble and Sandstone Company's nearby quarry, although the company did not exist until seven years after the present bridge structure was built. The primary name, "Northwest Road Bridge," is the name currently in common usage.

beams on either side of the web, and are secured underneath each beam with a plate and two nuts. Sets of fourteen longitudinal timber stringers (3"x12"), spaced at 14-inch centers, run perpendicular to the floor beams and rest on 4"x4" timber nailers fastened to the tops of the floor beams. The stringers support a timber deck, comprised of 8"x2-1/2" transverse wooden planks.

Lateral stiffening of the trusses has been accomplished through the design of the floor system as a horizontal wind truss, as outlined in William Douglas's first (1878) patent. The wind-truss chords, designed to resist both compression and tension, are the two lines of stiff metal struts, comprised of angles and tie plates, which run longitudinally between the floor beams along the centerline of each truss. These struts are riveted to the endposts and to angles attached to the outer ends of the floor beams. The floor beams themselves form the compression members of the wind truss web; the web's tension members are the 1-inch diameter lower lateral rods which cross between panel points under the deck and are fastened to the floor beams with anchor brackets and nuts.

According to data compiled by bridge historian Victor Darnell, the configuration, member sizes and details of this bridge are fairly typical of the lenticular pony trusses fabricated by the Berlin Iron Bridge Company.²

Repairs and Alterations

- The original wooden railings have been removed.
- A modern steel guardrail has been bolted to the inner face of each truss.
- There are some visible welded repairs to the diagonals and counters of the western truss.
- The timber stringers and wood plank deck have been replaced numerous times.
- The northern end panel floor-level struts of both trusses have welded steel reinforcement.

Historical Context

Located eight miles west of Springfield, the Town of Westfield was one of the earliest settlements in the Connecticut River Valley. The original village was situated in the crook of two rivers, the Westfield River (formerly the Agawam) and the Little River. By the middle of the nineteenth century, the town was an important stop at the junction of two railroad lines: the New Haven & Northampton Railroad which bisected the town north to south, and the Western Railroad (later the Boston & Albany Railroad) which bisected the town east to west. The combination of adequate water power and convenient rail transportation created a favorable climate for industrial growth in the nineteenth century. By 1906 the town was a thriving industrial center, boasting 36 whip manufactories and 23 cigar manufactories.³

² Victor Darnell, "Lenticular Bridges from East Berlin, Connecticut," IA: The Journal of the Society for Industrial Archeology, vol. 5, no. 1 (1979), pp. 21-24.

³ Town of Westfield, Mass., Souvenir 1906 (Westfield, Massachusetts: Westfield Times, 1906), p. 3.

Construction of Northwest Road Bridge

It is not known when the first bridge was constructed at this site, but historic maps of Westfield show Northwest Road crossing the Little River as early as 1831.⁴ Town records contain little mention of this crossing, presumably because it was one of the least significant of the town's many bridges.⁵ Northwest Road carried traffic between Russell Road (now U.S. Route 20), the Boulevard (now Western Avenue) and the center of West Parish (also known as Mundale), but Granville Road, a parallel road about one mile to the east, was a more convenient and more heavily travelled route.

The earliest known written record⁶ in which this crossing can be identified appears in the town's 1863 annual report, as follows: "*A good and substantial bridge has been built over Little river [sic], near the house of Orrin Cowles⁷ in accordance with a contract made by the last year's Board of Selectmen, at a cost of two hundred dollars.*"⁸ The next written record for the Northwest Road Bridge appeared in the local newspaper 23 years later, when the bridge was destroyed by a flood in January 1887:

*The bridge crossing Little River between the boulevard and West Parish, was carried off on Monday night. With the opportunity there to obtain the requisite material, a permanent structure with stone abutments should be built in the spring.*⁹

No further mention was made of the bridge—or of any inconvenience to travelers—until two months later, when the following item appeared in the newspaper:

*A new bridge must be built over Little River on the road leading from the boulevard to West Parish. As this is a cross road and comparatively little used, a structure of wood will answer the purpose and cost a great deal less than iron.*¹⁰

⁴ J.H. Goldthwait, "A Plan of Westfield from the Survey of 1831."

⁵ Frederick W. Beers's 1870 "Map of Westfield" shows at least 11 river crossings.

⁶ According to current city officials, the original manuscript town records were either badly damaged in a flood or destroyed when the town offices were moved to a new location.

⁷ The home of Orrin [also Oren] Cowles is identified at this location on a number of nineteenth-century maps. According to Eloise Fowler Salmond's 1934 book, Mundale, the West Parish of Westfield, Massachusetts, Oren Cowles was a stone mason who owned a portion of the land which would eventually be quarried by the Westfield Marble and Sandstone Company. [p.40.]

⁸ Annual Report of the Town of Westfield, 1863, n.p.

⁹ "*The opportunity there to obtain the requisite material,*" most likely refers to the quarry in proximity to the crossing. The fact that the author suggests waiting until spring to rebuild indicates the relative unimportance of this bridge to the town. Westfield Times and News-Letter, January 26, 1887, p. 2, col. 3.

¹⁰ Ibid., March 30, 1887, p. 2, col. 4.

At the annual town meeting on March 14, 1887, the town voted "*to build a bridge across Little River at West Parish at a cost not exceeding \$2,500.*"¹¹ The annual report of the town selectmen, published in April of that year stated:

*The bridge across Little River in West Parish was carried away by the ice and water January 25th, and a new bridge will be required there the coming spring; this bridge has been carried off by floods and ice at least four or five times within the last twenty-five or thirty years. A bridge eighty feet in length, of primitive character, with log abutments, common trestle work in the center, has always been an easy prey to the wild currents of the river. Such bridges should not be built by the town in the future. They may form a pretty foreground to a rustic picture, but for safety, economy and durability they are no longer needed. We therefore recommend that an iron bridge be built at this place with one span 75 feet in length, with road bed 16 feet in the clear, and substructure of stone.*¹²

By the end of April, the selectmen had contracted with the Berlin Iron Bridge Company of Berlin, Connecticut, a company that had already built several bridges in Westfield. A local newspaper reported on April 20, 1887:

*The selectmen have contracted with the Berlin bridge company of Conn., to build an iron bridge over Little river at West Parish. It is to be 75 feet long, one span, with stone abutments. This will make a substantial structure and will be a good deal cheaper in the end than a wooden one.*¹³

Local records hold no further mention of the Northwest Road Bridge until the town's annual report the following year:

*The bridge over Little River in West Parish, for which a specific appropriation was made, has been completed, with stone abutments and iron superstructure of 75 feet span. The location of this bridge was moved up stream about two rods [33 feet], which necessitated a change of the location of the approaches. The extra work for this was done by the town team. As newly located we think the road much improved and the bridge a permanent structure.*¹⁴

Lenticular Truss Bridges and the Berlin Iron Bridge Company

The lenticular (lens-shaped) truss is unusual among truss forms, in that it combines features of arch, cable and truss structural systems within a single structure. In a lenticular design, the outward thrust of the upper chord "arch" is identically countered by the inward pull of the

¹¹ *Ibid.*, April 6, 1887, p. 2, col. 2.

¹² "Report of Selectmen," in *Annual Reports of the Town of Westfield, 1886-87*, p. 10.

¹³ *Westfield Times and News-Letter*, April 20, 1887, p. 2, col. 5.

¹⁴ "Report of Selectmen," in *Annual Reports of the Town of Westfield, 1887-88*, p. 12.

lower chord "cable," while the stiff web verticals equalize the loads between upper and lower chords and act with the web diagonals and counters to stabilize the structure under moving loads.¹⁵ The lenticular truss is thus related to the bowstring arch truss (such as the 1841 patented design of Squire Whipple), but differs from the standard bowstring design in that the lenticular's upper and lower chords have mirror-image profiles.

Lenticular trusses had been built in France, England and Germany as early as the 1840s. In the United States, patents for lenticular bridges were granted to Edwin Stanley in 1851 and to Horace Hervey and Robert Osborne in 1855. Considering these earlier bridges and patents, it is somewhat surprising that in 1878 the United States Patent Office issued a patent to William O. Douglas of Binghamton, New York, for "*an elliptical bridge truss*." It is not known where Douglas received the inspiration for his design, but bridge historian Victor Darnell has suggested that Douglas may have created it without any knowledge of precedents.¹⁶ In any case, it was Douglas's patent that launched a very profitable career for a small New England metal company.

The Corrugated Metal Company, predecessor of the Berlin Iron Bridge Company, was a descendent of the Berlin, Connecticut, tinware industry that began in the 1740s. The manufacture of tinware in Berlin progressed to the manufacture of metalworking machinery, and from there to other forms of metal fabricating. In 1868 an East Berlin company by the name of Roys & Wilcox, manufacturers of tinner's tools and machinery, transferred part of their land to a separate company organized by Roys, the American Corrugated Iron Company. Three years later, the American Corrugated Iron Company sold the property to the Metallic Corrugated Shingle Company. The latter firm was reorganized in 1873 as the Corrugated Metal Company, manufacturers of corrugated iron building components, including iron roof trusses.

In 1877 the Corrugated Metal Company was on the verge of bankruptcy when S.C. Wilcox became president. Under Wilcox, the company obtained the exclusive rights to William O. Douglas's lenticular truss patent,¹⁷ and Douglas himself became associated with the company as Treasurer and Executive Manager. As evidenced by the company's early advertisements, the first lenticular bridges were apparently rather crude structures with elliptical (instead of parabolic) profiles for the upper chord. Under the direction of the company's chief engineer, Charles M. Jarvis, however, the lenticular design was soon perfected by changing the shape of the chords so that the pins were placed at points forming true parabolas.¹⁸ This change—dramatically illustrated in the firm's advertisements—was the turning point for the company, and the Berlin Iron Bridge Company (the name the company took in 1883) became one of the most successful American bridge-building firms in the late nineteenth century.

Company advertising in 1889 claimed that the firm had built more than 90 percent of the iron highway bridges constructed in New England in the past ten years. By the mid 1890s, the company had built more than 600 lenticular spans in the Northeast, about 50 of which have

¹⁵ Daniel L. Schodek, *Structures* (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1980), pp. 168-73.

¹⁶ Darnell, p. 19.

¹⁷ Ibid., p. 24.

¹⁸ *Engineering News-Record*, May 10, 1928, pp. 748-49.

survived to the present.¹⁹ However, after ten years of intensive bridge-building, the company began to shift its emphasis to metal-frame factory and mill buildings. In 1900, finding itself unable to compete with large fabricating firms outside of New England, the Berlin Iron Bridge Company merged with twenty-three other firms to form the American Bridge Company.

The lenticular metal truss, as refined by Charles M. Jarvis from William O. Douglas's rather crude patented design, was significant for its economical distribution of materials, based on a precisely calculated set of strains and a realistic-to-generous set of loading assumptions. The parabolic profile of the chords (modified by Jarvis from Douglas's elliptical or hipped form) come close to equalizing the strains in each chord segment; the varying lengths of the vertical members are close to being a moment diagram for the truss; and all truss members are precisely proportioned to carry specific, carefully calculated stresses. The resultant lenticular truss design—strong, efficient in its use of materials, and visually striking—was aggressively marketed by a company which specialized in its construction. The efficient use of materials allowed the Berlin lenticular trusses to be relatively inexpensive in their heyday (the 1880s through early 1890s). That fact, coupled with the Corrugated Metal Company/Berlin Iron Bridge Company's aggressive salesmanship, allowed the companies to dominate the market for iron highway bridges in New England and New York in the decade following Douglas's 1878 patent.

However, the exacting shopwork required for the fabrication of a parabolic truss, the limited opportunities it allowed for standardization and mass-production, and the problems it presented for the provision of sufficient lateral stiffness (particularly in the longer spans) were competitive disadvantages. Finally, as more and more towns and cities in the late nineteenth century took to hiring independent consulting engineers to design their new bridges (generally utilizing one of the standard Pratt or Warren truss types) the opportunities for a bridge-building company to successfully market its own, in-house design, were markedly reduced, and the lenticular design disappeared from competition.

¹⁹ Darnell, pp. 31-32.

Sources of Information

- A. Engineering Drawings: No engineering drawings have been found.
- B. Historic Views: No historic views have been found.
- C. Bibliography:

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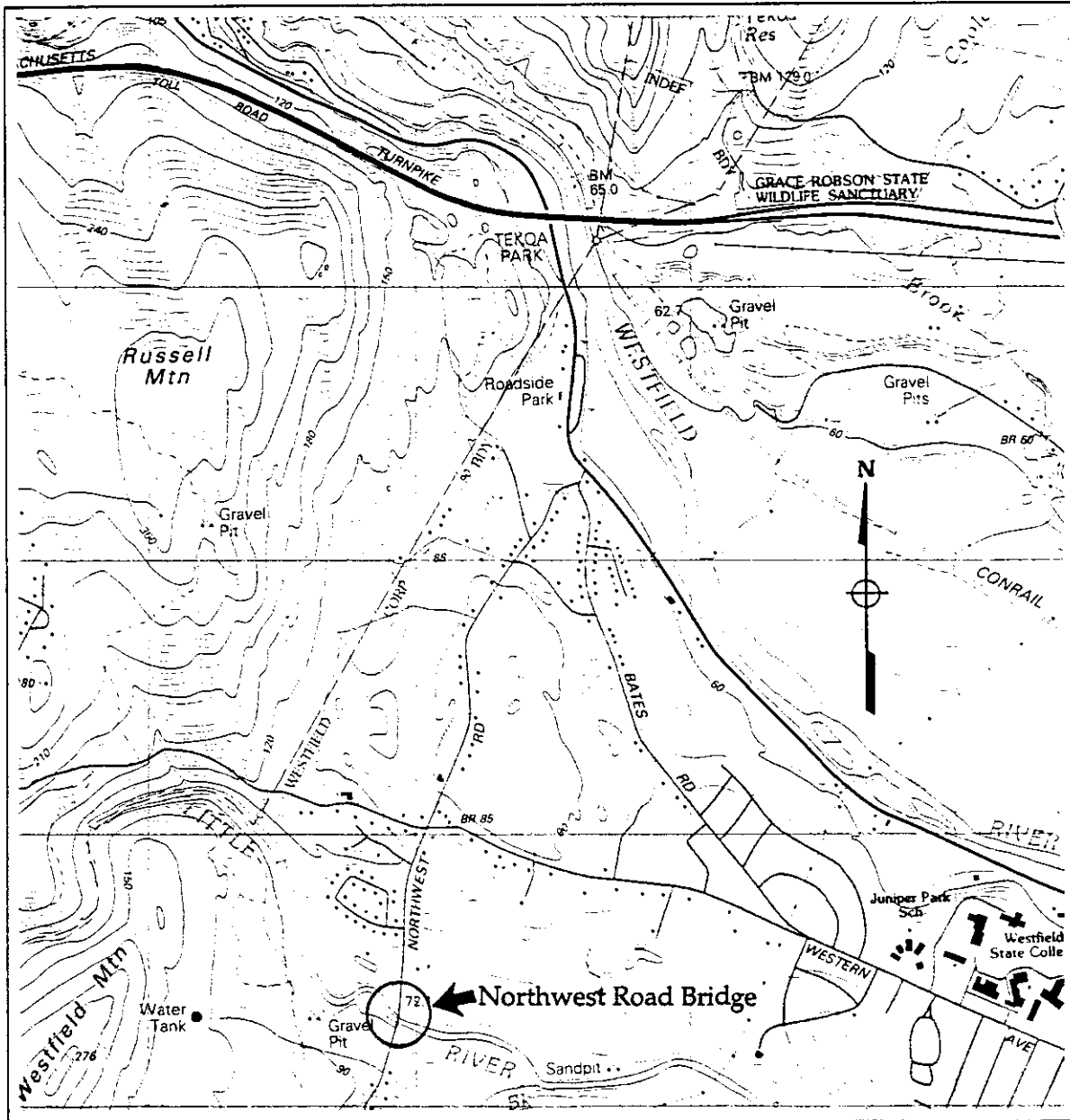
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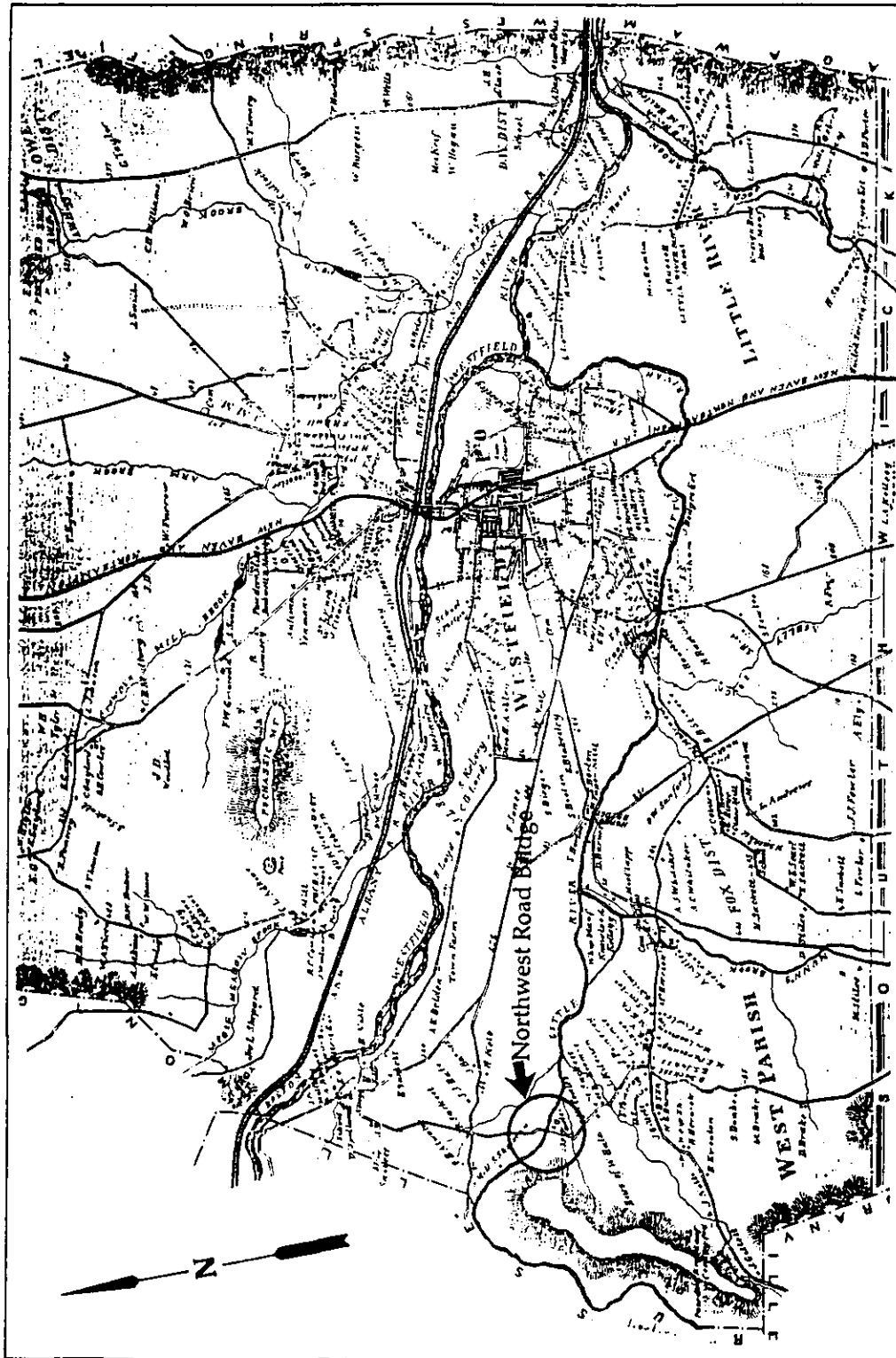
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Westfield Times and News-Letter. Westfield, Massachusetts, 1887-1888.

"William O. Douglas," biographical sketch, in Broome County Biographical Review, Broome County, New York. Boston, 1894, pp. 180-85.

D. Likely Sources Not Yet Investigated: All likely sources were investigated.

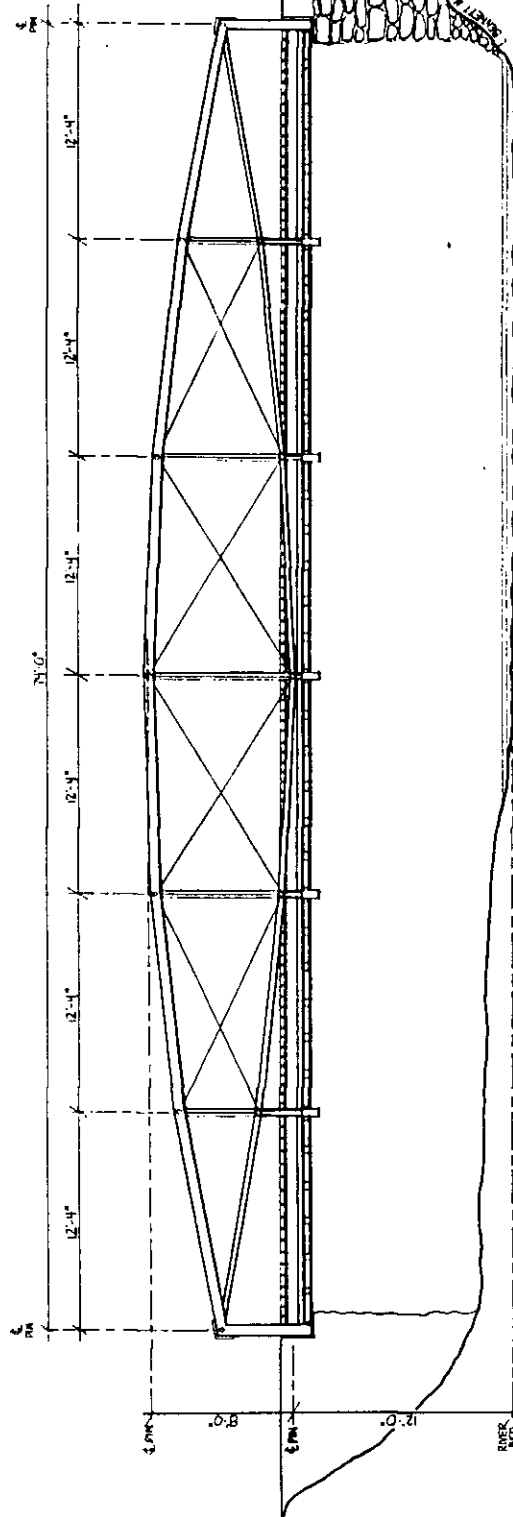


Location Map.
 [USGS Blandford, Massachusetts Quad., 1984.]



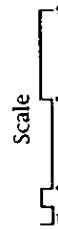
Historic Map, 1870.
 Beers, "Map of Westfield," in Atlas of Hampden County, Massachusetts, 1870.
 [Collection of Massachusetts State Library, Boston, Massachusetts.]

Northwest Road Bridge (Quarry Bridge) • 1887 Westfield, Massachusetts



NORTHWEST ROAD BRIDGE
(Quarry Bridge)
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Northwest Road, Spanning Little River
West Elevation



Sketch Plan, Northwest Road Bridge.
[Delineated by Lola Bennett, November 1996.]

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Contract No. 748. Span 74 ft. C. to C. Depth 8 ft. Roadway 18 ft.
Walks.....ft. each. 6 Panels, 12 ft., 4 in. Live Load, 100 pounds
sq. ft. roadway and.....pounds sq. ft. of Walks.
Live Load, per panel, per truss, 4.53. Tension, $7\frac{1}{2}$ to 6 $\frac{1}{4}$ tons sq. in.
Dead " " " " 1.54. Compression 6 $\frac{1}{4}$ to 5 " " "
Total 6.07. Angle, 90 deg.
Weight of Bridge exclusive of walk railing, 20600 pounds.
" " Iron Joist, " "
" " Sidewalk railing, " "

WESTFIELD, MASS.

3 Plates, 7 x $\frac{1}{4}$,	3.00 sq. in.
Arch { 1 Plate, 14 x 3-16,	2.03 "
4 Angles, 1 $\frac{1}{2}$ x 3-16,	2.48 "
	5.51 sq. in.
End Posts { 2-7 x $\frac{1}{4}$,	3.50 sq. in.
1-14 x $\frac{1}{4}$,	3.50 "
4-1 $\frac{1}{2}$ x $\frac{1}{4}$ Angle,	3.25 "
	10.25 sq. in.

Cables, 3 bars, 3 x 1, 0.6 sq. in.
Floor Line, 2 plates, 4 x $\frac{1}{4}$, and 3-1 $\frac{1}{2}$ x 3-16 Angles.
Web Posts, 4-1 $\frac{1}{2}$ x 3-16 Angle.
Web Ties: —
2d panel. Main, 1-1 $\frac{1}{2}$ in. ro., 1.00 sq. in. Corners, 1-1 $\frac{1}{2}$ in. ro.
3d " " 1-1 $\frac{1}{2}$ " 1.25 " " 1-1 $\frac{1}{2}$ "
Floor Beams, Web, 12 to 24 x $\frac{1}{4}$.
Fl's, 2-3 x 3 x 5-10 Angle.
3-3 x 3 x $\frac{1}{4}$ Angle.
Sways, $\frac{1}{4}$ in. ro., $\frac{1}{4}$ in. ro.
Railing, 2-8 x 1 $\frac{1}{4}$. White Pine.

If Iron Joists are used in above bridge, deduct 1500 pounds from weight of bridge, and add weight of Joists.

Design Book c1890
Berlin Iron Bridge Co

Specifications for Northwest Road Bridge.
Berlin Iron Bridge Company, Contract No. 748, Westfield, Mass., c.1890 design manual.
[Collection of Victor C. Darnell, Kensington, Connecticut.]

UNITED STATES PATENT OFFICE.

WILLIAM O. DOUGLAS, OF BINGHAMTON, NEW YORK.

IMPROVEMENT IN TRUSS-BRIDGES.

Specification forming part of Letters Patent No. 202,526, dated April 16, 1878; application filed March 28, 1875.

To all whom it may concern:

Be it known that I, WILLIAM O. DOUGLAS, of Binghamton, in the county of Broome and State of New York, have invented certain new and useful Improvements in Truss-Bridges; and I do hereby declare the following to be a full and exact description of the same, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a side elevation of a through-bridge; Fig. 2, a side elevation of a deck-bridge; Fig. 3, a side elevation of a swing-bridge; Fig. 4, a side elevation of a bridge with the roadway through the center of the truss; and Fig. 5 is a floor plan of the bridge, all constructed in accordance with my invention.

Similar letters of reference in the accompanying drawings denote the same parts.

My invention has for its object to improve the construction and efficiency of truss-bridges by combining as far as possible the maximum of strength with the minimum of cost; and to this end it consists, first, in the combination of parts forming an elliptical truss; and, secondly, in the construction of bridges with such trusses as I will now proceed to describe.

The truss, which constitutes the great part of my invention, is shown in the accompanying drawings composed of a compressive chord, B, and an extension-chord, C, firmly secured together at their ends A, with the struts E and diagonals or tension-rods D between them. The truss thus constructed is shown in Figs. 1, 2, and 3 in tipped form, and in Fig. 4 of parabolic form; but the general form is that of an ellipse or parabolic figure, which may be modified to suit circumstances or the taste of the constructor.

In Figs. 1, 2, 3, and 4 the thrust of the top chord B is resisted by the pull of the lower chord C; but in the form shown in Fig. 3 this is reversed when the span is open; then the pull is upon the upper chord, which resists the thrust of the lower chord.

The diagonals D are preferably arranged in pairs, although this is not absolutely essential, and are connected to the top chord B by pins S, passing laterally through them and the chord, while the lower ends are held in saddle-plates as at the points of their connection with

the lower chord C at the foot of the struts. At the center of the bridge, where the diagonals cross each other, both their upper and lower ends are fastened to the respective chords by pins 3, as shown in Figs. 1 and 3; or the trusses may be, and preferably are for long spans, connected by pins throughout, after the well-known details of the Pratt truss, as now usually employed.

The struts E and diagonals D bind the truss together, and transfer the strains toward the farthest point of support from them, while the chords B C transfer the greatest strain from the same point to the nearest point of support or abutment.

G is the floor-girder to support the roadway, having transverse joist, and either extends to the abutments below the chord C, as in Fig. 1, or above the chord B, as in Fig. 2, or through the center between the two chords B C, as in Fig. 4, or below the lower chord C, but unsupported by the abutments, as in Fig. 3.

In Figs. 1 and 3 the part G and the roadway are supported by rods F F, which run through the chords B C and the member G, and through or alongside the struts E, being secured by nuts at the top of the truss and beneath the part G. In long spans the tie-rod F does not run through to the top chord B, but is secured to the chord C at each panel-joint, as by a pin, a saddle-plate, thread and nut, or bolt-head.

In Fig. 2 the tie-rods are similarly connected at the top to the part G, and at their lower ends to the chord C; but in Fig. 4 their ends are held in the two chords and pass through the part G at about their centers.

In a bridge constructed as shown in Fig. 1, the member G serves to prevent the truss from moving bodily endwise, being attached along the center thereof to the chord C and to the bridge-seat. It also acts as part of the sway-brace system shown in Fig. 5, being subject to but little tensile and compressive strain, and forming no part of the supporting power of the truss. As a beam it carries the floor-joist between the tension-rods F, but is lighter in section when the floor-beams supporting longitudinal joist rest upon it at or near the rods F. For carrying joist upon it between such rods, it may be re-enforced by a T-bar, I,

Patent Text, Page 1,

"U.S. Patent No. 202,526, April 16, 1878," William O. Douglas.
[U.S. Patent Office Records, microfilm copies at Boston Public Library.]

202,526

(shown in Figs. 1, 2, 3, 4,) or otherwise increased in vertical diameter sufficiently to perform the office of a beam to carry transverse joist, as shown at right hand of Fig. 3.

In Figs. 1 and 3, H H are end posts which support the trusses when the roadway is along the bottom. They may be dispensed with when the floor-line is along the top of the truss or through the center, as shown in Figs. 2 and 4. In Fig. 4 the floor-line is unconnected with the truss at the ends.

Fig. 3 shows the different arrangement of the floor-joist and planking—the right-hand half having transverse joist and longitudinal planking, and the left-hand half having longitudinal joist and cross planking. This figure also shows the connections between the girders G and the trusses to form a bridge.

The strains are as follows: The members B, E, and H are compressive, and the members C, D, and F are tensile, excepting in the form shown in Fig. 3 for an open span, in which case the chord B is tensile and the chord C compressive, as previously stated. The strains upon the girder G and T-bar I are slightly compressive and tensile and transverse, accordingly as the joists are placed longitudinally or transversely with the truss.

All the tensile members may be made of any convenient form—round, square, or flat—

and all compressive members must be constructed with a proper ratio of diameter to the length, in order to properly resist compressive strain. The trusses or bridge may be constructed of iron or wood, or both.

I claim as my invention—

1. An elliptical bridge-truss consisting of the chords B C, united at their ends, with the struts E and diagonals D between them, substantially as described, for the purpose specified.

2. In combination with the elliptical truss, constructed as described, the suspension or tension rods F and floor-girders G, substantially as described, for the purpose specified.

3. In combination with the elliptical truss, constructed as described, the suspension or tension rods F, floor-girders G, and end posts H, substantially as described, for the purpose specified.

4. The combination of two or more elliptical trusses, constructed as herein described, with the floor-girders and joists, and the necessary decking to form a through, deck, or swing bridge, substantially as described.

WILLIAM O. DOUGLAS.

Witnesses:

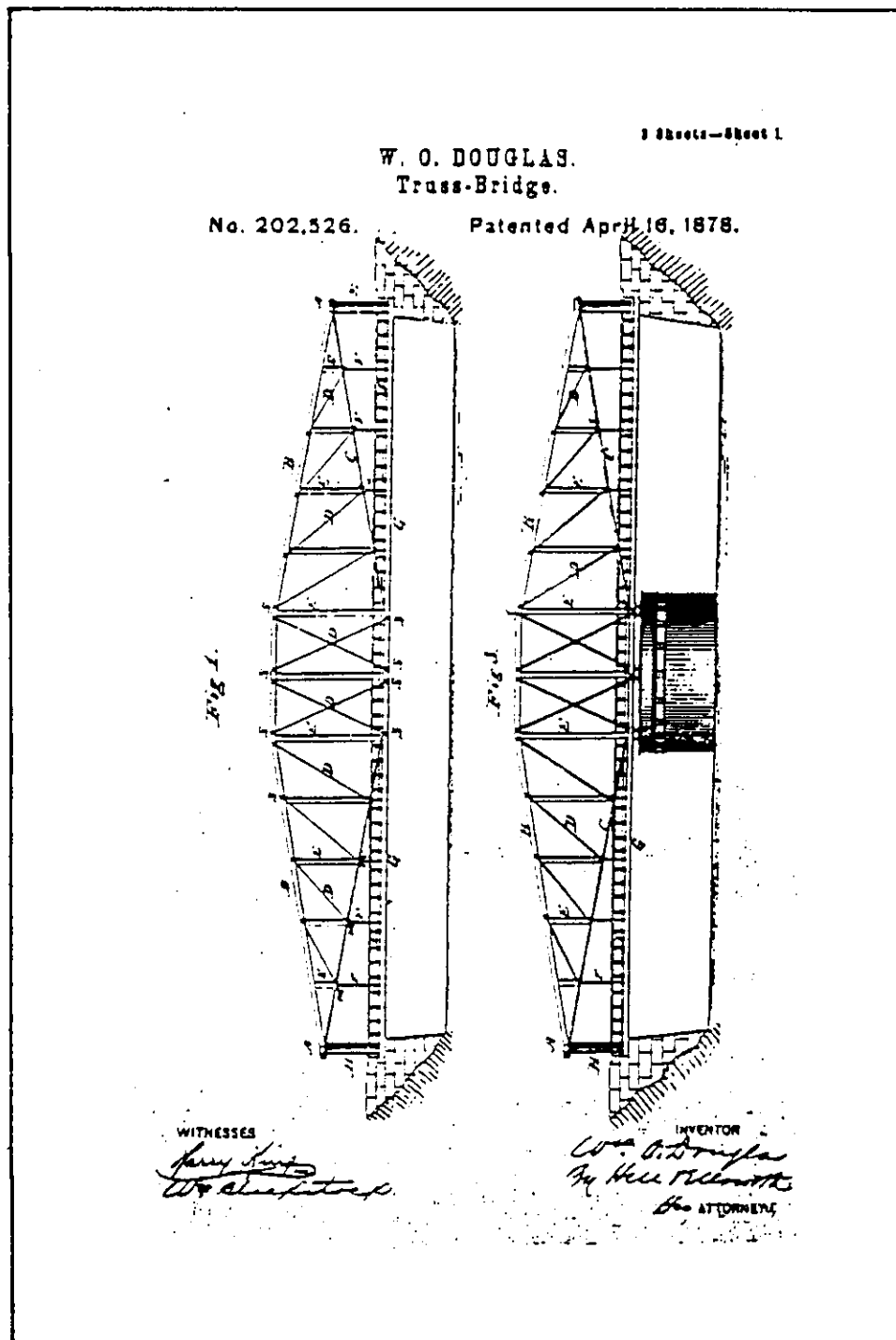
A. J. LYONS,

FRED. W. SMITH.

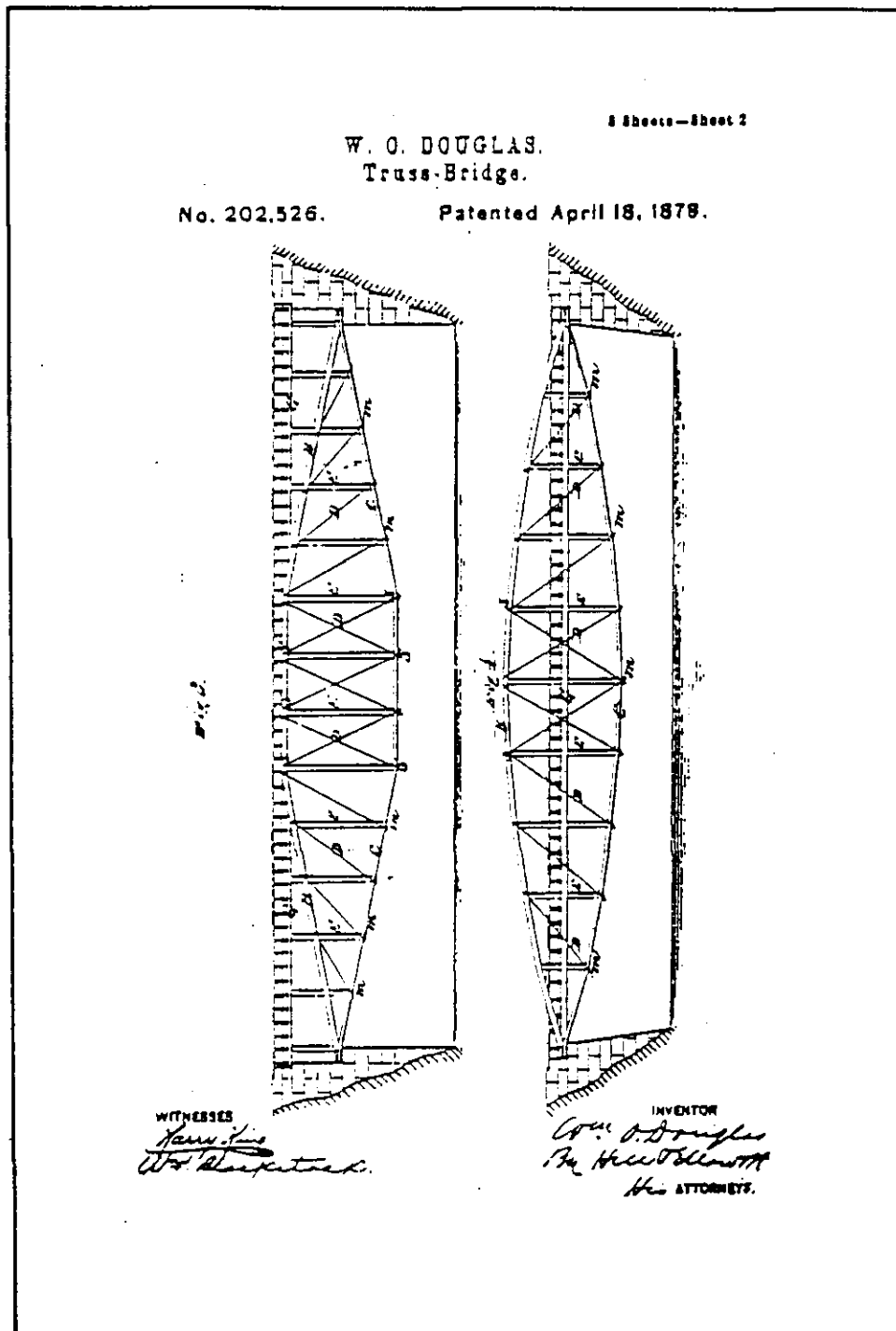
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"U.S. Patent No. 202,526, April 16, 1878," William O. Douglas.

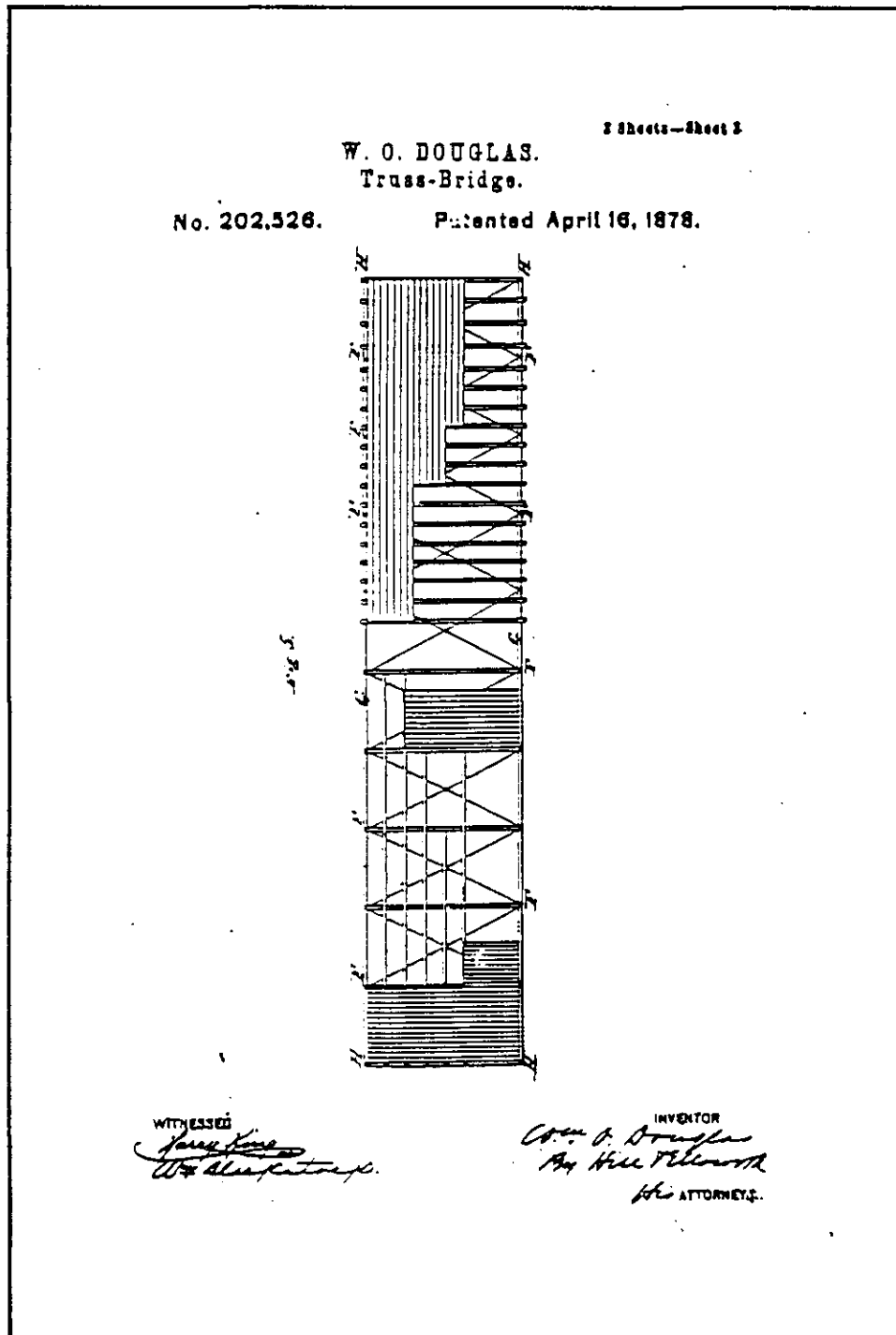
[U.S. Patent Office Records, microfilm copies at Boston Public Library.]



Patent Drawings, Sheet 1,
"U.S. Patent No. 202,526, April 16, 1878," William O. Douglas.
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Patent Drawings, Sheet 2,
"U.S. Patent No. 202,526, April 16, 1878," William O. Douglas.
[U.S. Patent Office Records, microfilm copies at Boston Public Library.]



Patent Drawings, Sheet 3,
"U.S. Patent No. 202,526, April 16, 1878," William O. Douglas.
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